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EDITORIAL NOTE

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In 1964, the Executive Committee of the Aviation Section of the Soviet National Association of Historians of Natural Science and Technology commenced publication of the thematic collections entitled "Pages from the History of Aviation and Cosmonautics", in which papers presented at the Sessions of the Section will be published.

These collections will be published by the All-Union Institute of Scientific and Technological Information (VINITI) in separate issues. The papers will be published by the offset printing method, together with news items, on the work of the Section and its groups.

This publication is designed for specialists in the field of aviation and rocket technology, and for the general public interested in the history of aviation and cosmonautics.

* Numbers in the margin indicate pagination in the foreign text.

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HISTORY OF AVIATION AND COSMONAUTICS

/4

IN MEMORIAM SERGEY GRIGOR'YEVICH KOZLOV



ABSTRACT. The history of aviation in the USSR, specifically in the rocket field, is reviewed from a personal viewpoint of national achievement. Separate papers are included on first rocket plane flights, achievements of the Leningrad Jet Propulsion Study Group and biographies of Russian aircraft designers. Details are given on construction, launch characteristics, altitude behavior, and propellant composition of illuminating rockets, aerophotosurvey rockets, atmospheric sounding rockets, and other experimental rockets for which dimensions, weight, maximum altitude, thrust, and other characteristics are tabulated.

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The USSR is rich in talented people. One of these geniuses was Professor Sergey Grigor'yevich Kozlov, a prominent worker in the science of aviation. He was an unusually gifted person, an outstanding teacher, an excellent designer, a thoughtful research worker, the author of a number of extremely interesting scientific works, the educator of a whole generation of aviation engineers, and

the mentor for many fledgling scientists. I should like to write in detail about this remarkable man: how he lived, struggled, learned, and taught others, but /5 this would be a long story rather than a brief article.

S.G.Kozlov was born on September 22, 1894 in the city of Volokolamsk, Moscow Oblast'. His father, Grigoriy Ivanovich, was a high school music teacher.

Sergey Grigor'yevich started his studies at a parochial school, then at a preparatory school, and later switched to a theological institute and seminary. This course of study was dictated by the straitened circumstances of the Kozlov family. They could not afford to pay Sergey's tuition fees, while tuition was gratuitous at the preparatory school and the seminary.

However, it was difficult for the impetuous youth, labile as quicksilver, to endure this study in the stagnant atmosphere of the seminary, a school for training clergymen. He left the seminary and began to study at home. His great abilities made it easy for him to prepare himself for the out-student examination for graduation diploma and to pass that examination.

In Autumn, 1913, Sergey entered the Imperial Moscow Polytechnic Institute (IMTU, now the MVTU imeni Bauman) where he met Professor N.Ye.Zhukovskiy, the famous Russian scientist - a meeting that was destined to determine the whole course of Sergey Kozlov's life.

Zhukovskiy was the father of Russian aviation. That name, even today, still glows in an aureole of immortal glory. To the students of those years it was the symbol of progressive science, a banner calling to scientific advance.

"Man has no wings and, in the ratio of muscle weight to body weight, is 72 times weaker than a bird... Yet I think that he will begin to fly, relying not on the strength of his muscles but on the power of his mind". These proud words by Zhukovskiy were imprinted in letters of fire on Sergey Kozlov's brain. His active nature called for knowledge, for heroic deeds.

Ever since those days, S.G.Kozlov was inseparably connected with aviation and aviation science. N.Ye.Zhukovskiy's lectures, the studies under his guidance at the theoretical aviation courses of the IMTU, and the personal contacts with the renowned scientist, helped Sergey Kozlov to find a fitting outlet for his outstanding abilities, perseverance, and love of work.

However, the war interrupted his studies, and we see S.G.Kozlov next at the Kachinsk School for Military Aviators, then at the Naval Aviators' School at Petrograd and Baku. It was not easy for him to study at these schools, first as an enlisted man and then as a common sailor, since most of the others were officers. The knowledge acquired at the IMTU under the influence of Zhukovskiy /6 helped Sergey Kozlov immensely here. It gave the slender small-stature buck private unquestionable authority with the airforce rookies, while his excellent performance of training flights put him in the top bracket as to rate of progress.

After the February Revolution, S.G.Kozlov was commissioned an officer and stationed for service on Oesel Island in the Baltic Sea. The difficult and dangerous tasks of a naval aviator commenced. He eagerly learned to fly the

famous M-9 hydroplanes of our famous designer D.P.Grigorovich.

Came the October Revolution: Brigadier S.G.Kozlov, of the Brigitovkoy Hydro-aviation Station, volunteered for service in the Red Navy in November 1917.

During the strenuous years of the Civil War, S.G.Kozlov fought against the White forces of Denikin, Yudenich, and Wrangel. On worn-out, obsolete aircraft he fought the White Guard pilots on up-to-date British and French machines supplied by the "Allies" to the White Guard Armies.

In 1919, S.G.Kozlov became Chief of the Air Division of the famous Volga-Caspian Flotilla. On one of his flights on a decrepit Nieuport-17, though wounded in the right hand and with the aircraft riddled by bullets, S.G.Kozlov still carried out a highly important reconnaissance of enemy artillery positions. For this exploit, he was given the Order of the Red Banner.

Thus, Sergey Kozlov's scientific career in aviation did not begin in the lecture-hall before the blackboard and not in the aerodynamic laboratory, but in the pilot's seat of a fighter plane, riddled by enemy bullets, fighting to the end with the White Guards, and winning a shining future with his very blood.

After the victorious conclusion of the Civil War, S.G.Kozlov resumed his education. In October 1921, he enrolled at the Institute of Engineers of the Red Air Force, renamed the Academy of the Air Force of the Red Army in 1922. S.G.Kozlov graduated from that Academy ahead of time in 1923 and commenced his work as a scientist and teacher. He gave exercises to the students of the Academy, wrote scientific papers and textbooks, invented, occupied himself with music, and did a large amount of social work. Avidly he plunged into the atmosphere of creative activity. Here his talents as a scientist broadened ever more.

The area of S.G.Kozlov's scientific interests covered an unusually wide /7 range. He lectured on propellers, supervised the computation and design office of the Academy, conducted in-course and diploma projects on propellers and hydroplanes, and designed an anemometry station. In 1935, he became Chief of the Department of Aircraft Structure and Strength. His papers were published in rapid succession - technical study of the semisubmerged propeller; design for a hollow Dural propeller (1924); nomographic method for aerodynamic aircraft calculation; aerodynamic propeller calculations; aerodynamic calculation of biplane fuselages (1927); selection of propeller and plotting of characteristics of propeller-engine systems; aerodynamic calculation of aircraft by the rpm method (1931); calculation of seaplane floats, and innumerable others.

It is impossible here to give even a brief outline of these papers. However, we must not fail to say a few words about two of them.

In 1927, S.G.Kozlov published an original method of aerodynamic calculation of the biplane fuselage. This simple and elegant graphoanalytic method, which came to replace the method of the German investigator Betz, permitted - under certain simplifying assumptions - a graphic solution of equations correlating coefficient of lift and angle of attack.

The simplicity and lucidity of this calculation method set it apart from all earlier methods, but furnished an entirely acceptable degree of accuracy. It found widespread use in the USSR and abroad.

Another very interesting study by S.G.Kozlov concerned the development of an aerodynamic method of calculating an aircraft by the graphoanalytic rpm method.

This method was developed by S.G.Kozlov in 1931, in collaboration with the famous Professor V.S.Pyshnov. The methods of aerodynamic calculation in use until 1931 were applicable only over tedious and time-consuming calculations to direct comparisons of the results of flight tests with the results of aerodynamic calculations.

The rpm method was free of this shortcoming and, immediately after publication, came into extensive use for calculating aircraft with piston engines and constant-pitch propellers. Much later, after the appearance of jet aircraft, a modernized rpm method was used in processing data for turbojet aircraft. /8

During the same years, S.G.Kozlov designed a propeller of magnesium alloy, special skids for aircraft, a tailless aircraft, an "invisible" aircraft, and a number of other objects.

In 1939, S.G.Kozlov was admitted to membership in the USSR Communist Party. He continued his work with still greater energy. He wrote a number of textbooks, designed interesting aircraft, revised a few previously published papers, and supplemented them by new material.

S.G.Kozlov did not confine himself to purely aviation subject matters. His inquisitive mind and his thirst for research induced him to solve the most varied problems. For example, he made an exact calculation of the strength of a bicycle wheel, a detailed calculation of the violin bow, and an acoustic calculation of the violin resonance box.

Music played a major role in Kozlov's life. He was a talented musician and played many musical instruments, including the violin, the viola, the violoncello, the flute, and a number of other wind instruments. Music was his favorite relaxation from scientific work and teaching. He took pleasure in performing in various musical ensembles, trios or quartets, and had a large musical library at home. Sergey Kozlov particularly loved Russian music with which he was well acquainted.

S.G.Kozlov was a skillful teacher. Working in the field of higher education, he made a profound study of the pedagogical views and the teaching experience of famous Russian pedagogues - Mendeleyev, Timiryazev, Zhukovskiy, and many others. Based on his study of this experience, he developed his own original methods of instruction. He prepared interesting lectures. One would think that, after giving the same course over and over again for many years, he would no longer have to take much trouble in preparing each lecture. Nevertheless, each lecture Kozlov gave was as though he were delivering it for the first time. With great agitation, carefully selecting every adjective, he would build up his phrases, frequently making sketches on sheets of paper, demonstrating how they

would look on the blackboard. Later on, he began to film a series of graphic material for each lecture, so as to illustrate his lectures without losing time on drawing. To avoid distracting his listeners by having them copy these materials, Kozlov had them mimeographed in advance, and passed out folders containing the copies.

In contrast to many instructors who give a purely descriptive course in aircraft structure, Kozlov strove to give his course on a high theoretical level, so as to impart some idea on the replacement of a given technical solution /9 by some other more advanced solution.

S.G.Kozlov built up his lectures so as to provide an exposition, in elegant mathematical form, of all the generalizations and laws he tried to confer to his listeners. Himself a good mathematician, he knew how to represent even complex concepts by relatively simple systems of equations, readily mastered by his students. This very same feature is also characteristic of his papers. Profound thoughts and sweeping generalizations are expressed in a relatively simple mathematical form.

The many years of study of the development of aircraft construction naturally led Kozlov to formulate a number of laws underlying this development. So it was that he became interested in the history of aircraft and the history of aviation engineering. This interest was furthered by the fact that he had come into contact with aviation in his early youth, that the entire development of aviation had unfolded before his very eyes, and that he had been not merely a witness but an active participant in that development. For this reason, when Kozlov's health compelled him to give up his strenuous teaching activities and he suddenly had leisure time, a luxury unheard of before then, he began seriously to concern himself with the history of aviation engineering. To this task, Kozlov brought his characteristically methodical habits and his scientific conscientiousness. After many years of work in aviation and aviation science, he had formed many ties with a large number of specialists. Contact with them had enriched his mind with much interesting information, pertinent figures, and observations on the history of aviation in the Fatherland.

As he collected such materials and as his files bulged with memos and notes, Sergey Kozlov began to understand with increasing discernment that the coordinated work of a large number of experts was a prerequisite for fruitful work on the history of aviation engineering. These thoughts and considerations led him to the Institute of the History of Natural Science and Technology of the USSR Academy of Sciences, where he soon became the director of the Section of the History of Aviation Science and Engineering of the Soviet National Association of Historians of Natural Science and Technology.

Soon he recruited for this Section a large group of specialists, many of whom had been prominent participants in establishing the mighty Soviet aviation. At numerous sessions of the Section, interesting papers were presented on various problems of the history of aviation engineering. Skillfully guiding the /10 work of the Section, he had soon established a base for spelling out the fundamental work on the history of aviation engineering.

Death prevented him from crowning his career with the completion of this

task. The duty of his colleagues in this work is to complete what he commenced.

Being a man of sweeping erudition and a thoughtful investigator, Sergey Grigor'yevich Kozlov was an irreplaceable consultant on the most varied branches of science and technology. During the last years of his life, he performed much fruitful work as a member of the Council of Experts of the USSR Patent Office. His participation in this work contributed to the correct solution of highly complex and controversial questions.

Many inventors whose ideas he instilled with life will remember with gratitude the attentive rigorous and sensitive specialist who deeply studied the gist of the questions and expertly threaded his way through the most tangled matters.

The high qualifications of this remarkable Communist scientist manifested themselves in full measure in this complex work: immense erudition, sensitivity to the new, objectivity in evaluating facts and events.

May the shining memory of Sergey Grigor'yevich Kozlov live long in the hearts of his friends and comrades.

V.A.Popov

THE FIRST USSR ROCKET PLANE FLIGHTS

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I.A.Merkulov

Over forty years ago, F.A.Tsander, one of the Pioneers of Soviet rocket building, prepared plans for an interplanetary ship using wings for motion in the atmosphere. He saw in the construction of winged rockets one of the keys of mastery of outer space.

The GIRD leaders had a high appreciation for Tsander's ideas, and from the very beginning the problem of winged rockets was on their list of major themes. One of the four GIRD teams concentrated their efforts on this exceptionally promising and yet highly complex problem.

The experimental rocket plane GIRD-RP-I was built in 1932 from plans by B.I.Chernanovskiy. It was a tailless aircraft of wooden construction. Its technical data are interesting. The wing span was 12.1 m, the wing area 20 m². The aircraft was 3.09 m in length and 1.25 m in height. The weight of the aircraft, without the engine, was only 200 kg. The aircraft had good dynamic data, its aerodynamic effectiveness (lift/drag ratio) was 16. The plans were to install the liquid-propellant rocket engine OR-2 of Tsander's design, burning gasoline and liquid oxygen, on the rocket plane. The engine was placed aft of the cockpit, and the fuel tanks - one for gasoline and two for oxygen - together with the cylinder of compressed nitrogen, in the wing center section.

The following are the design performance data of the rocket plane GIRD-RP-I:

	At Engine Thrust of	
	50 kg	100 kg
Takeoff time, sec	60	20
Rate of climb at sea level, m/sec	2.2	7.1
Maximum ground speed, km/hr	139	198
Ceiling, m	810	1400
Fuel consumption, gm/sec	250	420
Endurance, min	6	4
Flying range, km	13	20

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The rocket aircraft GIRD-RP-I entered its first stage of flight tests during which the crew flew the airframe (without the liquid rocket engine).

The next winged rocket flying machine to be built was a winged rocket. The preliminary work was started by the GIRD and was completed at the Jet Research Institute. On this rocket, a liquid rocket engine, using alcohol and liquid oxygen, was installed in its tail section. Its first flight was made on May 23, 1934.

Work to improve the winged rocket was continued during the following years. The engine ORM-65, burning kerosene and nitric acid and built in 1936, was in-

stalled on it. The data of this rocket, factory number 212, were as follows:

Construction of rocket	all-metal
Length	3.16 m
Span	3.06 m
Flying weight	210 kg
Weight of propellant	30 kg.

The rocket was provided with gyro-stabilization and automatic pilot systems. Its ORM-65 engine developed a maximum thrust of 175 kg. The rated thrust was 150 kg and the minimum thrust, 50 kg. Under rated conditions, the specific thrust was 210 sec at a pressure of 23 atm abs in the chamber. The engine could be started manually or automatically.

The ORM-65 engines withstood numerous starts. ORM-65 No.1 after 49 starts operated 30.7 min on the ground: 20 starts on the test stand, 8 starts on the winged rocket 212, and 21 starts on the rocket plane RP-318. The ORM-65 No.2 made 16 starts: 5 on the winged rocket 212 and 9 on the rocket plane RP-318.

From April 29, 1937 to October 20, 1938, ground firing tests were performed with the engine ORM-65 with an automatic starting system. On January 29 and March 8, 1938, flight tests of the winged rocket 212 were carried out. The log shows that starting and operating data of an ORM-65 engine which had made two 13 flights were satisfactory. The rocket was launched by the aid of a solid-propellant launcher.

In 1940, the first USSR manned flights on an aircraft with a liquid-propellant rocket engine took place. These historic flights were performed by the pilot V.K.Fedorov. A large amount of preparatory work preceded the flight tests.

The flights were made on a rocket plane RP-318, based on the glider SK-9. The technical data of this rocket plane were as follows:

Technical Data of Rocket Plane RP-318-1 with Engine ORM-65

Construction of rocket plane	wooden monoplane
Length	7.44 m
Span	17 m
Takeoff weight	700 kg
Propellant supply	75 kg
Engine operating time	100 sec
Thrust	150 kg.

The engine was installed in the tail of the fuselage.

The first ground firing test of the rocket plane took place on December 16, 1937. During this test, the engine operated for 92.5 sec. During the following 26 days it was started successfully 20 times more, with as many as five starts in a single day, for instance, on January 11, 1938.

After protective maintenance of the rocket plane, the firing tests were continued, and between February 3 and April 15, 1938, a total of nine starts were made with a maximum continuous operation of 230 sec (March 11, 1938).

Thus the rocket plane RP-318, already at the beginning of 1938, was completely prepared for the flight tests. For organizational reasons, however, the tests themselves took place only two years later. During this time, the engine designed for the rocket plane was modified, and in October 1939 it was overhauled and successful ground firing tests of the rocket plane RP-318 were made with the modified engine. It was then decided to make the flight tests. For a more complete test of engine operation in the air and for extending the flight as much as possible, the plane was towed by a conventional aircraft to an altitude of 2 km. At this altitude, the pilot Fedorov released the tow line and 14 changed to independent flight. Flying at a sufficient distance from the tow plane, Fedorov cut in the engine. It continued to operate until the propellant had been completely consumed. At the end of powered flight, the pilot successfully volplaned to the airfield.

The first flight of V.K.Fedorov on the rocket plane RP-318 was accomplished on February 20, 1940.

In 1941, the designer V.F.Bolkhovitinov designed a rocket fighter aircraft with an engine by L.S.Dushkin.

The Bolkhovitinov aircraft was a cantilever midwing monoplane of mixed construction with retractible landing gear. The nose of the fuselage carried two 20 mm cannon, ammunition, and a radio. Aft of this compartment was the pilot cockpit, covered with a canopy, and the fuel-tank compartment. The tail of the fuselage housed a liquid rocket engine.

Flight tests of the new aircraft were commenced in September 1941. At first, the aerodynamic properties of the aircraft itself were tested, without starting the engine. For this, the plane was towed into the air by a Pe-2 bomber.

On May 15, 1942 the test pilot G.Ya.Bakhchivandzhi made the first flight with the engine operating. Under the thrust of the engine, the aircraft took off from the airfield rapidly reaching a high altitude. Bakhchivandzhi made a smooth landing after flying his assigned route. Subsequently, other pilots made flights on this rocket fighter.

During World War II, Soviet aircraft designers worked on several other types of fighters with liquid rocket engines.

Thus Soviet designers and test pilots opened a new era in the history of our rocket engineering, the era of manned flights on winged rocket flying machines.

ON THE 75th ANNIVERSARY OF THE BIRTH OF THE AIRCRAFT
DESIGNER K.A.KALININ

/15

V.B.Shavrov

Konstantin Alekseyevich Kalinin (1889-1938), military pilot since 1916 and engineer since 1925 (graduated from the Kiev Polytechnic Institute), was one of the most famous of our aircraft designers from 1925 to 1937. He designed 16 aircraft types and their modifications, bearing designations from K-1 to K-13. His aircraft were extensively used in our civil aviation and, before the war, were more numerous than all other types of passenger aircraft.

He commenced his career in the Ukraine. K.A.Kalinin was sponsored by government circles and the public of the Ukraine. A production base was established for him; young engineers, graduates of Kharkov Aviation Institute, came to him. Designers such as I.G.Neman, A.Ya.Shcherbakov, Z.I.Itskovich, V.Ya. Krylov, P.G.Bening, A.A.Lazarev, and others began their careers under his tutelage.

K.A.Kalinin's aircraft had many features in common and often were original in configuration and construction. All were of the semi-cantilever or cantilever monoplane type, usually with a wing and horizontal tail surfaces of elliptic planform (a characteristic feature of Kalinin's aircraft). They were of mixed construction, the fuselage and vertical tail surfaces being invariably made of welded steel tubes, mostly with a fabric skin. The wings were usually of wood and likewise had a fabric skin. Nonferrous metals were used sparingly.

At that time wood, plywood, steel tubing and canvas were in relatively good supply. Structures built of such materials were simplest, cheapest, and most /16 easily repaired. This promoted widespread use of Kalinin's civilian aircraft, which were more economical than those of other designers, whether USSR or foreign.

Kalinin also designed military aircraft, which were highly individual in their features. From examples of these craft (K-7, K-12, and K-13), it is obvious that Kalinin was a bold designer and knew how to take technical risks to meet even the most difficult problems.

In 1920, after the end of the Civil War, workshops of the Kiev Airpark were established and placed in operation. In the Spring of 1921, military aircraft were repaired there. In 1923, a pioneer group, headed by Kalinin who was in charge of the design office there, was formed to design a passenger aircraft outside the conventional scope. He conceived the ingenious idea of using steel tubing salvaged from an obsolete "Voisin" aircraft. By the Summer of 1925, his passenger aircraft K-1 had been built.

The prototype was a semi-cantilever monoplane with a Salmson 170-hp engine. Its fuselage was welded of steel tubes, the first in the USSR, all of them trussed, without wire bracing. The pilot cockpit had a closed canopy (rare at

that time). The three-place passenger cockpit had a couch and two chairs.

On June 26, 1925 the K-1 made its maiden flight followed by a number of others; on September 17 it flew to Moscow by way of Kharkov, where, within two more weeks, its tests were completed. The aircraft was found to meet all requirements for a passenger aircraft and was rated for service in the Civil Air Fleet. It was admitted to series production. However, since the Salmson engine had already become obsolete, it was decided to replace it by the BMW-IV 240-hp engine which was then more practical, and to develop the aircraft further. This version was produced in the following year (1926), under the designation K-2.

/17



Konstantin Alekseyevich Kalinin
1889-1938

The K-2 hardly differed in dimensions from the K-1 (except for the engine) but its construction was of the all-metal type, as an experiment. The fuselage was welded of tubes with a skin of thin Kol'chug aluminum alloy over the cockpits. The wing and tail surface framework were of the same material, with a fabric skin. The structure proved to be relatively heavy. Even more important

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than that, it was also expensive, and the all-metal idea was dropped. The K-2 did have better flight performance and had four passenger places instead of the three in the K-1.

In 1927, the K-3 was put into production with the same contours and the same engine but a different function. It was now to be used as an air ambulance for two patients on stretchers and a physician or for three sitting patients and a doctor. This was the first hospital-type aircraft in the USSR. The flying range was five hours instead of four in the earlier model. The stretchers were placed on special stands and supports, according to a system developed by Dr. A.F.Lingart (who might rightly be called the founder of medical aviation in the USSR). The stretchers were put on board through a horizontal door.

The K-3 was followed by the K-4 in 1928. There were almost no differences, except for the more refined design and thus somewhat lower weight, using the same BMV-IV engine and put out in three modifications as a passenger, aerial photographic survey, or hospital plane. The K-4 passenger plane had a fuel supply for six hours of flight. The aerial survey plane K-4 was fully equipped for surveys with one or two cameras, photographing through a special hatch in the floor of the cockpit. It carried a crew of three: pilot, navigator, and photographer. Work on the aircraft was very comfortable. It was widely used for aerial surveys in various parts of the USSR.

The air ambulance K-4 differed little from the K-3. One of them had a 300-hp M-6 engine and was exhibited at the International Air Show at Berlin in 1929. Several of these were successfully used in the medical evacuation service.

The K-4 was put into series production in 1930. In all, 22 units were built. The series was restricted to this number since the BMV-IV engine was not produced in the USSR. The demand for air travel increased, and in 1929 a ten-place K-5 was produced, replacing the earlier models on the airlines.

On the K-4 "Chervona Ukraina", a record flight was made in August 1928 by the pilot M.A.Snegirev and the navigator I.T.Spirin, over the route Kharkov - Moscow - Irkutsk - Moscow - Kharkov. The introduction of Kalinin passenger aircraft into operation on the airlines of the Ukraine, during the first stages, met considerable opposition from the management of Ukrvozdukhput', who gave preference (as it proved, an unfounded preference) to the German Dornier aircraft. Kalinin's merit was to build the first civilian aircraft ever manufactured in series production. /19

The K-5 aircraft was a modification of all the earlier aircraft from K-1 to K-4, with the same mixed construction of steel tubes, wood, and fabric, but wire trusses were used in the fuselage framework, thus decreasing its weight. Dural was used only in the skin of the fuselage nose, in the canopies, in the construction of the seats and in the cantilever fairings. The aircraft was inexpensive and economical; with a 450 to 480-hp engine it could carry eight passengers over 800 km at a speed of 160 - 170 km/hr. The K-5 was one of the most popular aircraft of our fleet in 1930 - 1941; it was produced in series from 1931 to 1934, first using 450-hp M-15 engines and later the 480-hp M-22 version. A total of 260 aircraft, operated on almost all our airlines, was produced.

By 1934, the performance of the K-5 had already become inadequate, and an attempt at improvement was made by installing a more powerful engine, the 680-hp M-17. The speed was increased but the payload had to be reduced, for structural strength considerations. Nevertheless, for several tens of series machines, this engine substitution was used.

In 1930, the K-6 aircraft was built. It had an M-22 engine and was a two-place postal plane used for transporting news mats. Its speed was 210 km/hr, but on the whole it differed little from the K-5 and was therefore not produced in series. The K-9 and K-10 were light aircraft. Both of them had folding wings (to facilitate hangaring). They were not produced in series.

The K-7 was a giant aircraft. In dimensions and weight it was one of the largest in the world in those years. Seven 750-hp M-34 engines were installed on it. From a wing of elliptical planform and thick profile ran two tail booms of trihedral cross section and supporting the tail assembly. Under the wing, two heavy columns and eight separate outriggers carried large nacelles housing /20 the landing-gear wheels and the gun emplacements. Inside the columns were hatches for entrance to the wing whose central portions were considerably thicker than the height of a man (2.2 m). The aircraft was intended as a heavy bomber, and also was produced in a passenger version with 120 passenger seats in the wing. These seats could be replaced by 64 berths in 16 compartments. The military version was planned to carry four cannon and eight machine guns at a large bomb load.

The body of the aircraft, its wing, its tail booms and almost all other parts, were welded of steel chrome-nickel tubes. The framework was made of tubes, with the skin partly fabric and partly dural. All parts had truss ribs, including the tail booms. The wings had four spars, with the center spars designed as double tubes. Six engines were installed in front of the wing leading edge, using tractor propellers. The seventh engine was mounted to the trailing edge of the wing between the tail booms, using pusher propeller. Unfortunately, the M-34 engine at that time still had no reduction gearing and was essentially unsuitable for a giant aircraft. The relatively small propellers swept an unusually thick wing, markedly impairing the efficiency. The gross weight of the aircraft was 40 tons.

Designing of the K-7 aircraft began as early as 1929, and the final plans were approved in 1931. On July 29, 1933 the aircraft was substantially finished in construction and was placed on the airfield.

The bombing equipment was not yet installed. The newspaper "Izvestiya VTsIK" sponsored the K-7, which was to be turned over later to the Intelligence Squadron, imeni Gor'kiy as its flagship.

The first flight took place on August 11. Over a period of two months, this was followed by nine more flights without incident, except that various unavoidable design and production defects were revealed that required elimination. On November 20, over a measured run, a speed of over 230 km/hr was attained. The aircraft passed almost all plant tests. Its eleventh flight, on November 21, ended in a catastrophe. Before going into its measured run at /21 maximum horizontal speed, the aircraft unexpectedly began to lose altitude,

crashed to the ground, and burned.

The cause of the disaster was not established. Apparently, the servorudder and servoelevator, with their cable controls, whose dimensions exceeded the overall dimensions of the control surfaces, caused vibration of the tail assembly under certain operating conditions of the rear engine with its pusher propeller; in all probability, this was the cause of the failure and disaster. At that time, the problem of aircraft vibration had not yet been sufficiently investigated.

After the crash of the K-7, Kalinin designed other aircraft. At this period, his work mainly concerned the design of two original military aircraft, K-12 and K-13. However, the K-7 was by no means discarded. On demand by the management, two more K-7 were authorized, both with tetrahedral tail booms and a number of improvements; however, construction was stopped in 1935 when one of the prototypes had already been 60% completed.

The K-12 (or BS-2 "Firebird") was an experimental tailless aircraft with two 480-hp M-22 engines. It resembled the flying wing configuration on which K.A. Kalinin worked persistently, seeking ways to build a super-speed high-altitude aircraft, as a flying wing.

The K-12 had a normal trapezoidal wing, without sweepback but with considerable taper toward the tips on which wing-tip fins, known as wing disks, were installed. The wing profile was the well-known R-P type developed by P.P. Krasil'shchikov and still in use on many aircraft and gliders. In the K-12, however, the profile was very skillfully modified. Along almost the entire trailing edge of the wing there ran suspended flaps of the same R-P profile but inverted. If they had not been of the inverted type, the effect would not have been the same as that obtained by him. The outsides of the flaps functioned as ailerons, while the insides (close to the fuselage) operated as elevators or "elevons".

The design of the K-12 was commenced in 1934. It was a three-place bomber with front and rear shielded firing positions, with closed pilot cockpit and a bomb bay in the fuselage for 50 kg of bombs. To check the layout of the aircraft, an airframe geometrically similar but only half the size was built in 1934. This was used for almost a hundred flights, including aerobatics. The tests confirmed the correctness of the layout. /22

The construction of the aircraft, including its wing, was of welded chromenickel tubing, with a fabric skin using dural only for the surface of the pilot cockpit and the forward gun position. The aircraft contained no wood; it was decoratively painted with bright-red pictures of the "Firebird".

The aircraft was placed on the field in August 1936. The flight tests showed that a tailless aircraft could fly reliably and show good stability and controllability. Confidence in it was so great that it was shown in the Tushino air show of August 18, 1937. It was then returned to the plant and, after applying the finishing touches, was placed into series production. It was the first true tailless bomber in the world.

Almost simultaneously with the K-12, the K-13 was built and tested. This was a two-engine bomber with biplane tail assembly, although it was not as successful as the K-12. However, all work on both aircraft was suddenly stopped in Spring of 1938, since Kalinin, at the peak of his career, fell victim to the arbitrary and vicious procedures arising from Stalin's cult of personality. He did not reach the age of 50.

Today, a quarter of a century later, it is clear that K.A.Kalinin achieved almost everything that was practically possible in the field of medium civilian aircraft, characteristic of the period of the First Five-Year Plan. He had already passed to designing more complex and faster aircraft, but his ideas in this direction could not be realized.

FROM THE HISTORY OF THE LENINGRAD JET PROPULSION
STUDY GROUP (LENGIRD)

/23

V.V.Razumov

At the beginning of the 1930's, the Leningrad Oblast' Council of the OSOAVIAKhIM organized a jet propulsion study group, in the public domain, under the name of LENGIRD.

I had read books by K.E.Tsiolkovskiy and Professor N.A.Rynin on interplanetary travel, and had been visiting Professor Rynin repeatedly. We had long talks on interplanetary trips and rockets and, on my own initiative, with his council, I had done much work on preliminary sketches for a high-altitude rocket burning liquid propellant.

At that time, I was consultant to the Leningrad branch of the Dirigible Balloon Works, where I met the famous balloonist P.F.Fedoseyenko. Once, in a conversation with him, I told him that I was very much interested in rockets and that I had often met Rynin with whom I had discussed problems of interplanetary travel.

To my astonishment, Fedoseyenko reacted with great interest and stated that it was very timely and that, in fact, the Office of Aerial Technology of the Leningrad OSOAVIAKhIM was just then planning to organize a volunteer group to study and build rockets.

He suggested that I participate as a volunteer in the OSOAVIAKhIM work on jet propulsion and, for his part, promised to talk about it to Rynin and other colleagues. He also told me that the well-known author of popular science subjects, Ya.I.Perel'man, was also attracted by this project.

Over 30 years have passed since then, but these events were carved into /24/ my memory. I remember that in the next few days (this was in the Spring of 1931, around the end of March) I visited Rynin, discussed the calculation of rocket flight by my own method and, among other things, told him that I had joined the OSOAVIAKhIM and would work as a volunteer on rockets at the Office of Aerial Technology.

Rynin replied that OSOAVIAKhIM had also talked to him about it and that he, Gazhala, and Perel'man intended to participate in this work.

We met at numerous occasions, either at Rynin's house or at my own, having long conversations, making various proposals, and drawing plans on the development of work with rockets and the prospects of interplanetary travel.

So it was that the initial group for jet propulsion study was organized at the Leningrad OSOAVIAKhIM. It consisted of Rynin, myself, Gazhala, and Perel'man.

Ye.Ye.Chertovskoy, vice chairman of OSOAVIAKhIM, was fantastically active in organizing the rocket group. He recruited V.A.Artem'yev, B.S.Petropavlovskiy, A.N.Shtern, and others for the initial work.

In November 1931, at the Army and Navy House, the first public meeting of the activists took place, and LENGIRD was organized. The entire original group was elected to the presidium.

N.A.Rynin, in his introductory speech, told of the objects and problems of LENGIRD; this was followed by my report on my work on high-altitude rockets, on the future aspects of using rockets for exploration of the stratosphere and subsequent investigation of interplanetary space.

At the end, the meeting elected the executive committee of LENGIRD, consisting of V.V.Razumov as chairman, Ya.I.Perel'man as vice chairman, N.A.Rynin, and M.V.Gazhala.

At the next meeting, toward the end of 1931, about 40 persons were present. At this meeting it was decided to form smaller units for work on the study of jet propulsion.

After my paper on the work I had done, the activists were asked to pick their unit. In all, five groups were set up: Research: M.V.Gazhala, director; Planning and Designing: V.V.Razumov, director; Propaganda: Ya.I.Perel'man, group leader; Laboratory: I.N.Samarin, group leader; Rocket Site: Ye.Ye.Chertovskoy, 25 group leader.

Some five or six of those present, including the leaders, joined each group.

LENGIRD had no permanent building for its technical work. Each activist worked at home. The seminars on current problems also took place in our own homes, often at my apartment.

More extended conferences were held in a room in the attic of the Leningrad House of Technology, which Chertovskoy obtained for us.

V.I.Shorin, Chairman of the Leningrad OSOAVIAKhIM, took an active part in the formation of LENGIRD and afterwards also assisted in our work. In particular, he raised funds to pay for workmen and materials to build and test rockets, and also arranged for assignments of LENGIRD members to Moscow to coordinate their work with that of the Moscow branch of GIRD.

We were then able to link up with the Institute of Wire Communications, in whose workshops, at the personal requests of Shorin, a large high-altitude rocket with an aluminum body was built. Activists did the work on an unpaid basis in their free time, which naturally had an adverse effect on the work and interfered with its successful performance.

Draftsmen and workmen were paid from the funds of the Leningrad OSOAVIAKhIM; however, these payments were inadequate [redacted] had to be supplemented from other sources. For example, to raise funds for building the large high-altitude rocket, at the request of V.I.Shorin, I was sent to Moscow to see M.N.Tukha-

chevskiy, Deputy Peoples' Commissioner of Defense of the USSR.

My trip was successful; we received 15,000 rubles to pay the workmen for building rockets in the workshops of the Leningrad Institute of Wire Communications.

The activists, as already mentioned, were all volunteers. I should like here to recall one of the enthusiasts of that time on rocket work. This was the activist and public servant, aviation mechanic S.Lotsmanov, who was always to be found at my home drawing rockets.

I must also mention the active work of Ye.Ye.Chertovskoy, Vice Chairman of OSOAVIAKhIM, and P.F.Fedoseyenko who, like me, worked in the public interest as a volunteer. /26

Both of them devoted a good deal of work and effort to organization and operations of LENGIIRD. For example, Ye.Ye.Chertovskoy, enthusiast and activist in rocket work, organized the first meetings, called for volunteers and found space for the meetings, while P.F.Fedoseyenko often visited the LENGIIRD meetings and actively participated in their work.

Let me now tell you about the work done by the individual groups.

Research Group:

In December 1931, M.V.Gazhala organized seminars for the study of jet propulsion at LENGIIRD. Lessons were given on higher mathematics, mechanics, and jet propulsion theory. The lectures were delivered by Gazhala and Samarin up to the end of May 1932. In October 1932, courses were organized for engineering and technical workers at the Leningrad House of Technology, at which lectures on jet propulsion theory were delivered by Gazhala, Petropavlovskiy, and Rynin.

In addition, in November 1932, courses on jet propulsion were organized at Leningrad for persons with elementary or advanced technical education. The lessons given were on higher mathematics, mechanics, thermodynamics, chemistry, jet propulsion theory, strength of materials, and materials science. The instructors were Gazhala, Samarin, Petropavlovskiy, and A.N.Shtern.

In September 1932, at the workshops of one of the Leningrad plants, small rockets of three different types with solid-propellant rocket engines were built: high-altitude rockets, rockets with panels, and ballistic rockets.

Tests were made at the proving grounds on the OSOAVIAKhIM terrain by the leader of the Research Group, M.V.Gazhala. The results of the tests were satisfactory. Twenty metal rockets were also designed and ordered at machine shops for various charges of solid motors for altitudes up to 1 km. Gazhala supervised execution of the order.

Planning and Design Group:

In 1932, under the direction of Engineer V.V.Razumov, the following rockets

were designed: A powder rocket flare with a climbing range of 5.0 km, a photographic rocket with solid motor for an altitude of 10.0 km, and a recording rocket with solid motor for an altitude of 10.0 km.

In the same year, the design of a liquid-propellant rocket with a rotary engine was started. It operated on liquid oxygen and gasoline, and had a ceiling of 5.0 km.

In 1933, the group made calculations and sketches for high-altitude rockets with ramjet liquid engines for a climbing range of 60, 100, and 300 km.

Subgroups to develop rocket engines for solid and liquid propellants were organized in the Planning and Design Group. Let us now consider the work of these subgroups.

The solid rocket engine subgroup, from 1932 to 1935, developed plans for solid motors under the supervision of V.A.Artem'yev. The engines designed by him were used in all experimental rockets, and successfully passed the tests on the proving grounds at the OSOAVIAKhIM, under the supervision of Gazhala. In 1934, experimental rockets with these solid motors were launched at the Zmeykova Station of the Aerological Institute in the city of Slutsk. These rocket tests were reported in the newspaper "Na Strazhe" (organ of the Central and Moscow Councils of OSOAVIAKhIM) in its issue of October 28, 1934. The article "Experimental Rockets" gives brief characterizations of the small experimental rockets and photographs of the large experimental rocket designed by Engineer Razumov.

The development of plans in the liquid-propellant engine subgroup was under the supervision of Engineer A.N.Shtern, who proposed the design of a rotary engine, LRD-D-1, burning liquid oxygen and gasoline.

Propaganda Group:

From January to December 1932, Ya.I.Perel'man gave lectures and reports at the large Leningrad plants on the problems and plans for stratospheric exploration by rockets and on flights to other planets. His lecture "By Rocket to the Moon" was highly successful.

Ye.Ye.Chertovskoy and M.V.Gazhala also took active part in the propaganda ²⁸ efforts at the Leningrad plants. They also organized groups on rocket-engine models.

Work of the Laboratory Group:

At the end of 1932, organization of a testing facility was commenced under the supervision of I.N.Samarin. These facilities comprised a laboratory and workshops. The work included preparation of a project containing all above-enumerated objects with sketches, descriptions, and cost estimates.

According to plan, the testing station was to check all units and equipment before installation on the rocket and to test the entire rocket, fully assembled,

before its delivery to the rocket site.

The testing station provided appropriate test stands in isolated hangars for testing and rating the thrust of engines using solid and liquid propellants. The tests, in the established order, were to be made from remote-control consoles, in special rooms of the laboratory and test station.

In addition, the testing station also provided individual stands for testing the piping in assembled form, along with the tanks, apparatus and equipment for launching, combustion cutoff and proper operation of the liquid-propellant engines.

The primary tasks of the laboratory were to check and recommend propellant compositions of suitable ballistic characteristics for rockets with solid-propellant engines and the components for rockets with liquid-propellant engines; to check and calibrate the research instruments, optical and photographic apparatus, gyroscopic devices, etc. to be installed on the rocket, and to check the onboard radio control and the ground-based radio indicators.

The laboratory was also to be equipped with all apparatus and instruments needed to do work relating to rockets with solid and liquid motors.

In first approximation, it was assumed that the labor-consuming production of parts of the rocket, such as casing, tanks, stabilizers with control surfaces, etc. would be taken over by the workshops of the Leningrad Machine Works.

For this reason, the workshops of the testing station were only to assemble the rockets and install the tanks, build and install the piping, safety valves, /29 etc. This work made it necessary to have assembly and installation shops, fitting shops and copper-working shops, which were equipped with the necessary assembly stands, scaffolding, work benches, desks, etc.

However, the plan was never carried out, owing to lack of funds.

Work of the Rocket-Site Group:

The mission of the Rocket-Site Group related primarily to all work on rocket launching, delivery of the rockets to the launch pad, and all safety measures, specifically shelter and observation bunkers. In addition, all of the launching equipment was under the jurisdiction of this group.

Ye.Ye.Chertovskoy was the soul of the organization of all tests. Under his guidance, a sketch of the rocket site for launching experimental rockets was prepared.

Such was, in brief, the work of the individual groups of LENGIRD.

Let us now discuss, in somewhat greater detail, the work of the Planning and Design Group.

I. SOLID-PROPELLANT ROCKETS

1. Photographic Rocket Designed by Razumov for a Climbing Range of 10,000 m

The proposed photographic rocket (Fig.1) for an altitude of 10 km, was designed to photograph ground localities.

The rocket consisted of a detachable nose (1) carrying a camera, a body (2) to which stabilizers (4) with rudders (5) were mounted, and four rocket engines (3) installed in the forward section. Pyroxylin smokeless powder was scheduled as the propellant.

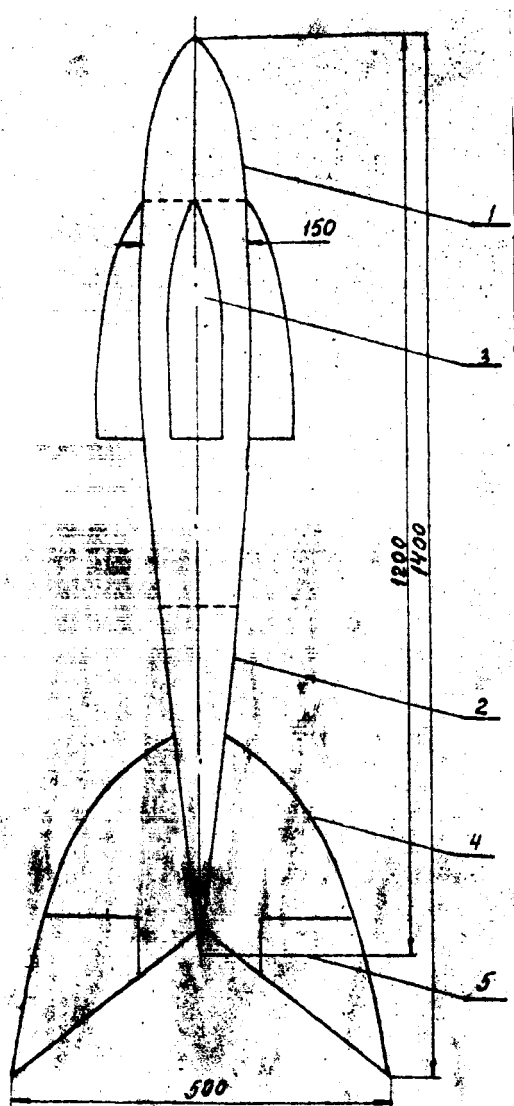


Fig.1

It was intended to obtain a photographic record of the rocket ascent, by measuring a base line on the ground which the rocket photographed from a specified altitude.

The camera was placed in the rocket nose, was ejected when the rocket reached its ceiling, and automatically took pictures during descent.

Smooth descent of the camera was /30 ensured by a parachute. The weight of the entire ejected camera was taken as not exceeding 5 kg.

It should be noted that also the body of the rocket was equipped with a parachute to provide smooth descent.

A draft of the project was prepared for the Leningrad branch of the Research Institute for Geodetics and Cartography. On January 23, 1932, the project was delivered to Comrade Buzayev. On February 14, 1932 a copy was sent to N.A.Rynin.

2. Rocket Flares Designed by Razumov, /31 for a Ceiling of 5.0 km; Tactical and Technical Requirements for Planning and Construction of a Prototype Experimental Rocket for a Ceiling of 5000 m*

A. Purpose and object of rocket:

Possibility of supplementing or replacing searchlights, and also of dazzling

enemy pilots under antiaircraft fire*.

B. Project-technical requirements for planning and building of rockets:

- 1) Portability of rocket manufacturing facilities.
- 2) Simple operation with the rocket not requiring specially trained personnel.
- 3) Rocket charge preparable at one of the chemical plants of Leningrad.
- 4) Manufacture of the rocket costing as little as possible and permitting mass production.
- 5) High initial rate of ascent.
- 6) Ceiling of 5000 m in vertical ascent from the liftoff point.
- 7) Possibility of obtaining illumination at any altitude within the limits of the ceiling (use of a variable-time fuze or sequential charges for various altitudes).
- 8) Impacting of rocket not to cause damage or start fires on the ground.
- 9) Launching sequence from the pad to ensure proper timing of firing order so as to provide continuous illumination if needed.
- 10) Launcher to be designed so as to permit launching from the ramp at an angle of $45^\circ - 90^\circ$ with all-around traverse of 360° .
- 11) Starter and rocket launcher to be of simplest design and to require no special launch sites.
- 12) All structural materials for the rocket to be produced in the USSR. /32
- 13) Rocket to illuminate specific air regions, if possible without illuminating the ground.

General Description of the Rocket (Fig.2)

The rocket consists of: a head (1) which houses an illuminating device, a parachute, and an ejector; four solid motors (2); an axial boom (4) to whose top the motors are mounted by retaining springs (3). The rear part of the boom is provided with four stabilizers (5) attached to the boom (4) over shafts (6); in the working position, the stabilizers are blocked by the stops (7).

* The tactical and technical requirements and the general description of the rocket discussed here are given in the same form in which they were prepared in 1932.

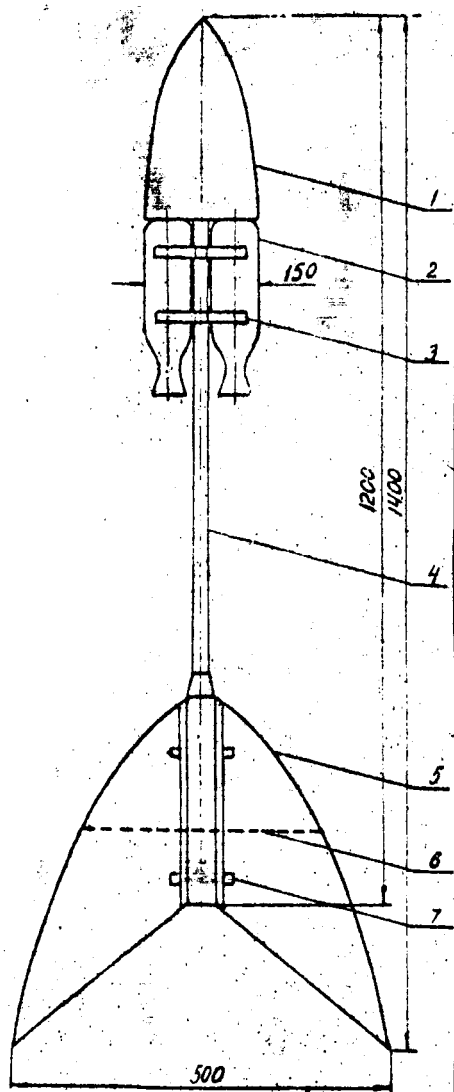


Fig. 2

When the rocket reaches the predetermined altitude, the head (1) is separated by the ejector. Together with the nose section, a parachute with the illuminating device is also ejected. In descending, the head spins with its ogive downward and the parachute is deployed above it; the illuminating device begins to operate and illuminates a given region of the air, while the head screens the light and prevents illumination of the earth's surface.

At the same time, the remainder of the rocket, consisting of the burned-out solid motors (2), the shaft-boom assembly (4), the ejector and stabilizers (5), begins to descend, turning with the motors (2) pointed toward the ground. Simultaneously with its rotation, 133 the rocket body, with the stops (7) released by the ejector, frees the stabilizers (5) whose surfaces, which now begin to rotate, function as propeller blades thus ensuring a slow descent of the rocket body to the ground.

The nose (head) section of the rocket is made of aluminum, the engine combustion chambers and nozzles of stainless steel, and the shaft-boom assembly of thin-walled steel tubing. The stabilizers are of aluminum.

The engines are individually dismountable. The number installed on a given rocket depends on the altitude required. They are placed alongside the rocket and manually forced into the spring clamps (3), without the use of tools or other devices.

The rocket propellant is smokeless pyrox-
ylin powder with the following characteristics:

Density	1600 kg/m ³ ;
Volume of gaseous combustion products of 1 kg powder, at 0°C and 760 mm Hg, including water vapor	84.0 dm ³ ;
Combustion temperature	2460°C;
Ignition point	168 - 172°C

The preliminary design of the rocket flare was delivered on February 26, 1932 to N.A.Rynin for Comrade Kotov, Chief of Staff, Military Artillery Academy. On May 5, 1932, the draft was delivered to M.V.Gazhala for the construction of prototypes at the Leningrad Machine Works. Tests were performed under his control in September 1932 at the rocket site on the terrain of the Leningrad OSOAVIAKhIM and gave satisfactory results.

3. Recording Rocket Designed by Razumov for a Climbing Range of 10.0 km

The recording rocket with a ceiling of 10.0 km (Fig.3) was designed for procuring data on barometric pressure, temperature, and density of the atmosphere, at an altitude of 0 - 10 km above sea level. The required instrumentation was to be installed in the head of the rocket.

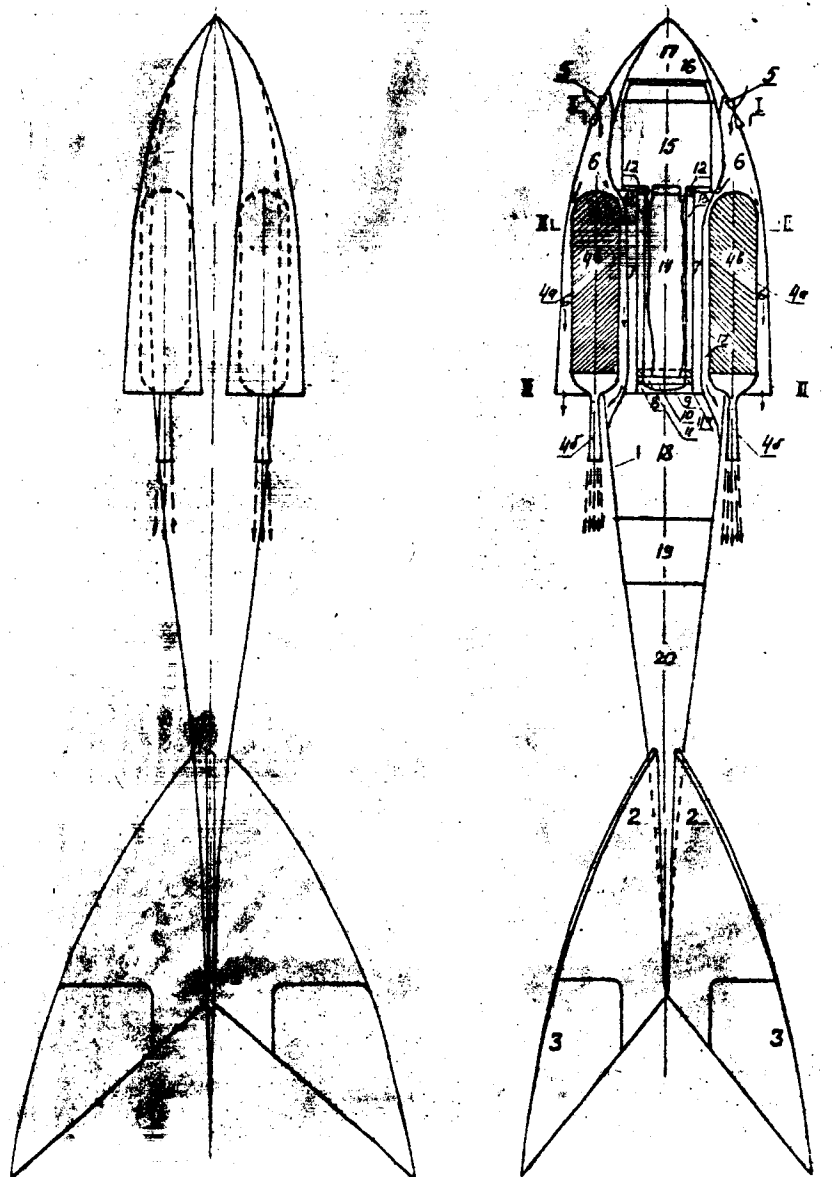


Fig.3

The plan provided that, on reaching maximum altitude, the nose section would automatically separate from the body of the rocket and the rocket head, with the recording instruments, would descend smoothly by parachute. The body, head, and

stabilizers were of aluminum. The rocket had four rocket engines housed in the front section. Smokeless pyroxylin powder was to be the propellant. /35

The solid motors were provided with steel combustion chambers with nozzles of heat-resistant steel. The outer combustion chamber was cooled by a current of air passing through annular passages in the rocket body.

The rocket comprised the following principal parts:

1) Case; 2) stabilizers; 4) rocket engines consisting of a) combustion chambers and b) nozzles.

A cooling system with the coolant passages (6) and the vents (5) was to be built in the body of the rocket. At the locations of the combustion chambers, the rocket body was provided with thermal insulation (7). The mechanism for separating the rocket head with the recording instruments and for ejecting the parachute consisted of the following parts: wooden base plate (8), cups for the ejecting charge (9), explosive charge (10), piston (11), two rubber sealing rings (12), and four struts of dural tubing (13), to keep the parachute (14) in the folded position.

The recording instruments were placed in the cylinder (15), to which the shroudlines of the parachute (14) were attached. To diminish the ejection shock on ejection of the cylinder with the recording instruments (15), a rubber shock absorber (16) was used, and, in addition, a buffer section (17) was placed in the rocket nose to soften the impact of the rocket head, together with the cylinder (15) and the recording instruments, at the instant of landing.

Figure 3 also shows: remainder of the body (18), containing a gyroscope section (19) for controlling the rudders (3), and, finally, the rear section of the rocket body (20) carrying the four stabilizers (2).

The preliminary design of the rocket was developed under orders of the LENGIRD Research Group for presentation to the Leningrad Geographic Institute. The rocket was subsequently simplified and, in smaller sizes, was built in the versions: high-altitude with plates and ballistic type, which were given the designation "M.V.Gazhala experimental rockets".

These rockets were tested on the rocket site on the OSOAVIAKhIM terrain, using V.A.Artem'yev solid motors. The altitude reached by these rockets was of the order of one kilometer.

II. ROCKETS WITH LIQUID-PROPELLANT ENGINES

/36

1. Recording Rocket of Razumov Design with LRD-D-1 Engine of Shtern Design

Figure 4 is a drawing of the rocket with a rotary engine LRD-D-1 operating on liquid propellants.

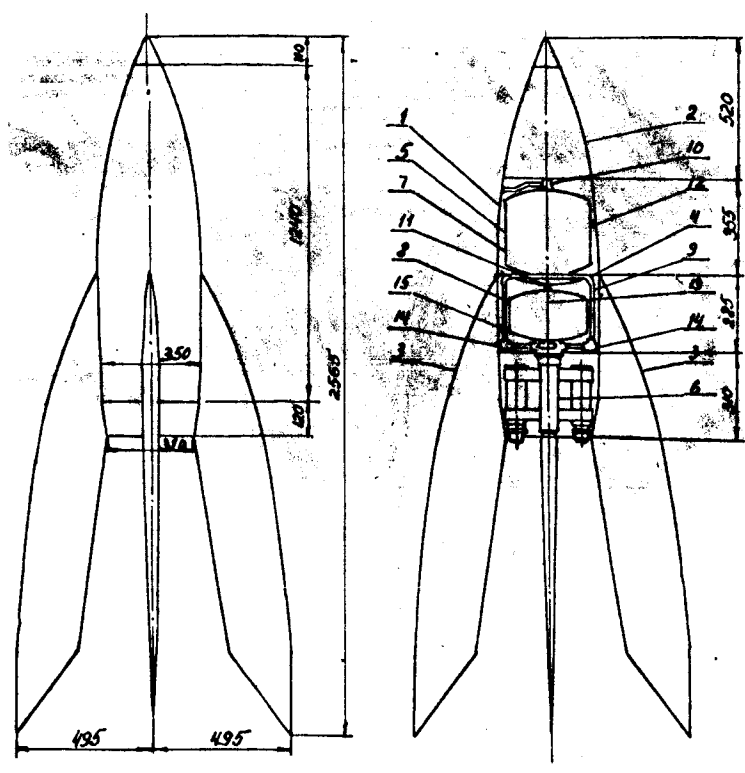


Fig.4

In 1934, at a conference on exploration of the stratosphere, N.A.Rynin, in his paper "Methods of Mastering the Stratosphere" called this rocket the "Razumov-Shtern recording rocket"*.

The rocket consists of the following parts: 1) Body; 2) head; 3) stabilizers; 4) partitions; 5) insulation; 6) engine; 7) liquid oxygen tank; 8) gasoline tank; 9) piping for liquid oxygen; 10-11) safety valves; 12) valve for feeding lox; 13) same, for gasoline; 14) check valves for lox; 15) same, for gasoline. 137

A shock absorber was installed in the rocket nose. Beyond the head, a special cylinder housed the recording instrument compartment; below the cylinder, there was a folded parachute. The instrument power source was placed in the next compartment. The center section of the rocket carried the tanks of liquid oxygen and gasoline. The total weight of the rocket body, including shell of the frame and partitions, was 14.11 kg. A liquid oxygen tank of 18.3 liters capacity held 17.8 kg liquid oxygen and weighed 2.56 kg, while the gasoline tank of 7.7 liters capacity held 4.89 kg gasoline and weighed 1.85 kg. The engine was placed inside the rear section of the rocket. The rear section had four streamlined stabilizers on the outside.

* Cf. Trudy Vses. Konf. po Osvoyeniyu Stratosfery, 31/3-6/4/1934, p.681. Publ. Dept., USSR Academy of Sciences, 1935.

The LRD-D-1 engine designed by A.N.Shtern, was a rotary rocket engine. The propellant was fed through pipes running along the arms on which the rocket engines were mounted. The engine nozzles were cut off obliquely so that the reactive force had a component in the horizontal plane controlling the lever perpendicularly. Both lever and engines were attached to the bearing of the vertical shaft. This formed a rotary system in which the propellant was fed to the engine under the action of centrifugal forces. Figure 5 gives a schematic sketch of the engine. It should be pointed out that the rotating masses not only supply fuel to the engine but also produce a gyroscopic effect ensuring stability in flight. The material of the engine was steel. The total weight of the rocket was 90 kg including the structural weight of 36.2 kg (body assembly, 20.2 kg; engine, 16 kg) while the weight of the propellant was only 25% of the overall weight of the rocket, or 38% without counting the weight of the payload.

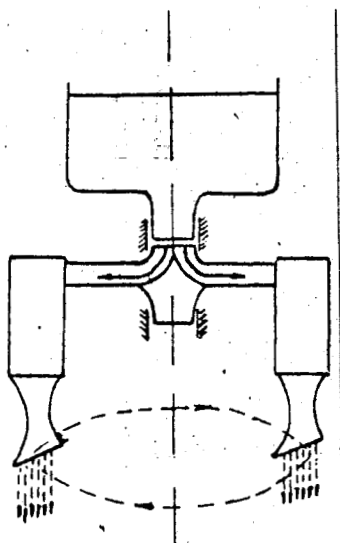


Fig.5

The thrust of the engine was 200 kg at an exhaust velocity of 2000 m/sec. The walls of the combustion chamber and the nozzles were cooled by liquid oxygen evaporated in cooling jackets.

The rocket was built at the shops of the Lenin- /38 grad Wire Communications Institute in 1932.

The rocket, its drawing, and individual engine parts (combustion chamber and nozzle) were exhibited at the All-Union Conference on the Conquest of the Stratosphere from March 31 to April 6, 1934.

At that time, the LRD-D-1 engine had not yet been completely developed and its completion had been indefinitely postponed; therefore, it was decided to launch the rocket with a solid motor for preliminary aerodynamic check tests and observation of its behavior in flight. The rocket was finally launched at the end of 1934 with a solid-propellant engine designed by V.A.Artem'yev.

2. Rockets of Razumov Design with Liquid-Propellant Rocket Engines

Recording rockets of Razumov design with liquid-propellant rocket engines (altitude 60 and 300 km) went only as far as the first stage of preliminary design, completed on February 27 and November 25, 1933 respectively. The author drew the plans of these rockets for LENGIRD on his own initiative, in consultation with N.A.Rynin.

Both these rockets were designed to secure data on barometric pressure, temperature, and volumetric weight of the air of the upper layers of the stratosphere. Detailed data of the rockets are given in Table 1, and Fig.6 shows the approximate positions of the onboard devices and equipment, using the following numeration:

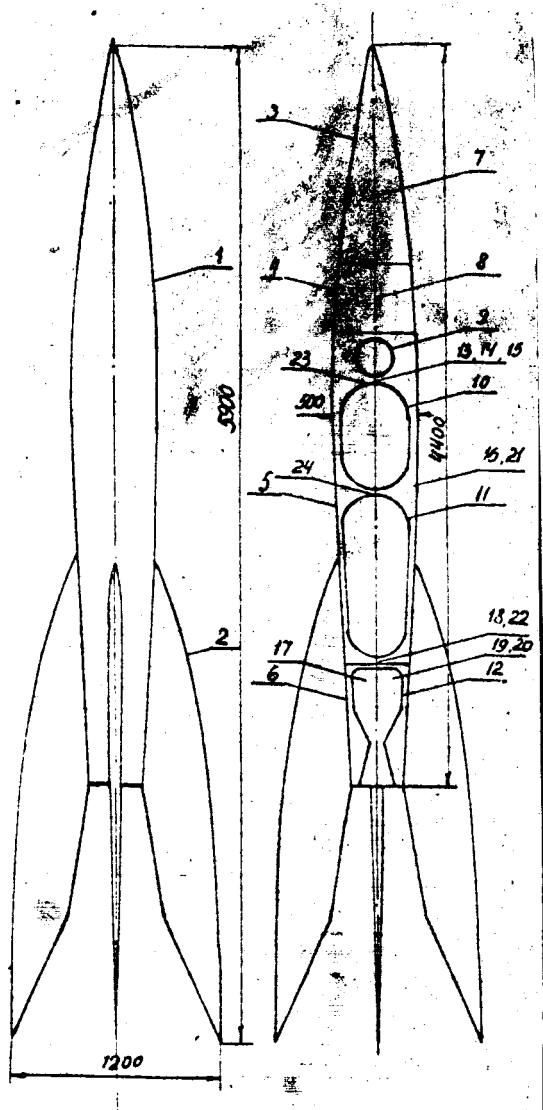


Fig. 6

1) Body; 2) stabilizers; 3) nose section; 4) compartment for recording instruments; 5) center section; 6) rear section; 7) parachute; 8) recording instruments; 9) compressed-air cylinder; 10) gasoline tank; 11) liquid oxygen tank; 12) engine; 13) reducing valve, 150/25 kg/cm²; 14) valve for launching rocket; 15) compressed-air pipe through reducer (13) to gasoline and liquid oxygen tanks; 16) pipe to gasoline injectors; 17) gasoline injectors; 18) liquid oxygen pipe in cooling jacket of combustion chamber and nozzle; 19) collector; 20) oxygen injectors; 21) no-return valves in gasoline line; 22) no-return valves in liquid oxygen line; 23) safety valves in gasoline tanks; 24) safety valves in liquid oxygen tank.

The body (1) was to have been made of Kol'chug aluminum alloy (dural). Outside the body, in the rear, there were four stabilizers (2). The rocket was designed for vertical ascent and therefore had no rudder.

There were four compartments inside the body.

The first compartment (3) forming the rocket nose housed the parachute (7), designed for smooth descent of the entire rocket after reaching its maximum altitude.

The second compartment (4) was to contain the recording instruments (8).

The third compartment (5) forming the center section of the rocket contained: a spherical compressed-air tank (9) under a pressure of 150 kg/cm², from where, through the reducing valve (13), compressed air under a pressure of 25 kg/cm² passed through the pipe (15) into the gasoline tank (10) and the liquid oxygen tank (11). 42

In the compressed air line, in front of the reducing valve, there was a valve (14) for launching the rocket.

The fourth compartment (6) (forming the rear section of the rocket) carried the engine (12), a ramjet engine operating on liquid propellant.

TABLE 1

ROCKETS FROM THE PLANNING AND DESIGN GROUP OF LENGIRD

Name of Rocket	Date of Project Initiation	Dimensions		Diameter of Body	Weight		
		Overall Length of Rocket	Length of Body		Rocket with Fuel	Fuel	Payload
		Meters		Kilograms			
1	2	3	4	5	6	7	8
Razumov photo-survey rocket	Jan. 1932	1.35	1.2	0.25	26	6	5
Razumov illuminating rocket	Feb.18, 1932	1.2	0.5	0.15	18	3	2
Razumov recording rocket	Mar.23, 1932	2.11	1.79	0.23	30	10	5
Razumov recording rocket with Shtern IRD-D-1 engine	Nov.25, 1932	2.665	1.47	0.35	90	22.69	31.41
Razumov recording rocket with liquid rocket engine	Feb.27, 1933	3.62	2.45	0.35	95	43.7	11.0
Razumov recording rocket with liquid rocket engine	Nov.15, 1933	5.9	4.4	0.50	150	110	10.0
LENGIRD experimental rockets	1934	0.5	-	0.05	0.5	-	-
Razumov recording rocket	1934	2.665	1.47	0.35	90	22.69	31.41

(cont'd)

TABLE 1 (cont'd)

Engine	Fuel, or Fuel Components	Reactive Thrust on Liftoff, kg	Calculated Exhaust Ve- locity of Gases m/sec	Maximum Velocity of Rocket, m/sec	Maximum Altitude of Rocket, km	Duration of Rocket Flight	
						With Operating Engine, sec	After Engine Burnout, sec
9	10	11	12	13	14	15	16
Four solid motors	Smokeless pyroxylin powder	270	1860	446.5	10.0	4.33	50
Four solid motors	Smokeless pyroxylin powder	81	1860	348	5.0	4.35	40
Four solid motors	Smokeless pyroxylin powder	148	1860	744	10.0	12.7	63
Rotary engine	Gasoline, 4.89 kg; liquid oxygen 17.8 kg	200	2000	-	5.0	-	-
Ramjet engine	Gasoline, 12.5 kg, liquid oxygen 31.2 kg	1000	2000	958.4	60.0	28	98
Ramjet engine	Gasoline 30 kg; liquid oxygen 80 kg	1571	2000	2170	300	51	222
Ramjet engine	Powder grain	-	-	-	-	-	-
Ramjet engine	Powder grain	-	-	-	-	-	-

The engine consisted of a combustion chamber and a nozzle, both cooled by liquid oxygen evaporated in cooling jackets. Fuel was supplied to the combustion chamber by compressed air with the aid of a system comprising: compressed air tank (9), pipelines (14), (15), and (16) with their fittings, pressure reducing valve (13), valves, ignition device, and injectors, in short the entire equipment required for starting, stopping, and correctly operating the engine.

Unfortunately these rockets were not further developed, owing to unforeseen circumstances.

* * *

To summarize some of the results of LENGIRD's work, let us recall that the beginning of the 1930's saw the organization, in Leningrad, of a Center where enthusiasts of rocketry and interplanetary travel assembled. It must be borne in mind that the staff working at LENGIRD on the creation of rockets included many members of widely differing levels of education, with different specialties and different occupations.

LENGIRD did valuable work in making rocketry popular, thus helping to establish cadres of volunteer specialists on rocket engineering. The Center worked in close contact with the Moscow GIRD. Exchange of reports was practiced, and directions of future work were outlined. In exchange of practical experience, the Moscow GIRD was given the draft of one of the LENGIRD rockets and an original calculation of its flight (allowing for gravity and resistance of the ambient medium), performed on the basis of my method.

In conclusion, I might state that LENGIRD's work was of indisputable significance in the development of the idea of rocket engineering in the USSR, the creation of new rocket designs, and the popularization of scientific and technical thinking on the conquest of space.

IN THE SOVIET NATIONAL ASSOCIATION OF HISTORIANS OF
NATURAL SCIENCE AND TECHNOLOGY

The Aviation Section of the Soviet National Association of Historians of Natural Science and Technology continued its work in 1962 - 1964. The Section today has about 200 members, including mostly everybody who is working in the field of the history of aviation science and engineering in the USSR. The largest groups are working in Moscow (82 members), Leningrad (65 members), and Kiev (31 members). The Section also has aviation historians from Tbilisi, Riga, Kharkov, Saratov, Tartu and other cities. During the period just past, the activity of the Section was in the following main directions:

- a) investigation of various questions of the history of aviation science and engineering;
- b) preparation of a collective work: "Fifty Years of Aviation Science and Engineering in the USSR" (Aviatsionnaya nauka i tekhnika v SSSR za 50 let);
- c) preparation of a history of the leading design offices of the USSR aircraft industry;
- d) compilation of a handbook of biography and bibliography of USSR workers in aviation science and engineering.

Below, we give an outline of the work of the principal groups of the Section.

Moscow

From September 1962 to June 1964*, nineteen sessions of the Section were held, at which the following papers and communications were presented:

Anoshchenko, N.D.: The First Balloon Flight Specifically for Scientific Observations, Arranged by the St. Petersburg Academy of Sciences on June 30, 1804 (On the 160th Anniversary of the Flight of Academician Ya.D.Zakharov [O pervom polete aerostata spetsial'no dlya nauchnykh nablyudeniye, organizovannom Peterburgskoy Akademiyey nauk 30 iyunya 1804 g. (K 160-letiyu poleta akademika Ya.D.Zakharova)]).

Anoshchenko, N.D.: Organization and Work of the "Flying Laboratory" (On the 45th Anniversary of its Establishment) [Organizatsiya i rabota "Letuchey laboratorii" (K 45-letiyu so dnya osnovaniya)].

Anoshchenko, N.D.: Pre-History of Soviet Gliding (Predystoriya sovetskogo planerizma).

Bazurin, R.G.: Brief Historical Survey of the Main Trends of Space Study

* Reports of the Sessions held up to Summer of 1962 were published in Tr. Inst. Istorii Yestestvozn. i Tekhn. Akad. Nauk SSSR, No.38, Moscow (1961), pp.321-324; No.45, Moscow (1962), p.256.

- (Kratkiy istoricheskiy obzor osnovnykh napravleniy kosmicheskikh issledovaniy).
- Belolipetskiy, V.I.: Pages from the History of the Mechanics of Space Flight (Iz istorii mekhaniki kosmicheskogo poleta).
- Bondaryuk, M.M.: Application of the Theory of Academician B.S.Stechkin to the Design of Ramjet Engines (Prilozheniye teorii akademika B.S.Stechkina k sozdaniyu pryamotochnykh vozdushno-reaktivnykh dvigateley).
- Bubnov, I.N.: Main Stages of Development of the Space-Rocket Boosters of the United States. Analysis of the Degree of Success of Launchings of American Artificial Earth Satellites and Space Vehicles (Osnovnyye etapy razvitiya kosmicheskikh raketnositeley SShA. Analiz rezul'tativnosti zapuskov amerikanskikh iskusstvennykh sputnikov Zemli i kosmicheskikh letatel'nykh apparatov).
- Znamenskiy, G.A. and Merkulova, N.M.: On the 60th Anniversary of the Wright Brothers' Flight (K 60-letiyu poleta brat'yev Rayt).
- Kaznevskiy, V.P.: The 25th Anniversary of the Launching of the World's First Rocket with a Ramjet Engine (25 let so dnya zapuska pervoy v mire rakety s PVRD).
- Kozlov, S.G.: A Long-Term Plan of Publication of Papers on the History of Aviation and Rocket Engineering by the Institute (O perspektivnom plane publikatsii rabot po istorii aviatsionnoy i raketnoy tekhniki v izdaniyakh Instituta).
- Kozlov, S.G.: Working up Questions of the History of Aviation in the Union Republics and the Large Industrial Centers of the USSR (O razrabotke voprosov istorii aviatsii v soyuznykh respublikakh i krupnykh promyshlennykh tsentrakh strany).
- Matyuk, N.Z.: The Activities of N.N.Polikarpov's Design Office (Deyatel'nost' konstruktorskogo byuro N.N.Polikarpova).
- Merkulov, I.A.: On the 25th Anniversary of the Launching of the USSR's First Two-Stage Ramjet-Powered Rocket (K 25-letiyu so dnya zapuska pervoy v SSSR dvukhstupenchatoy rakety s vozdushno-reaktivnym dvigatelem).
- Merkulov, I.A.: On the First Flights of Rocket Aircraft in the USSR (O pervykh v SSSR poletakh na raketoplanakh).
- Merkulov, I.A.: The 30th Anniversary of the First Experimental Flight Studies on the GIRD Ramjet Engines (30 let so vremeni pervykh letnykh eksperimental'nykh issledovaniy pryamotochnykh vozdushno-reaktivnykh dvigateley GIRD-a).
- Mosolov, I.Ye.: Lenin and Aviation (Some Documents and Other Materials) [V.I.Lenin i aviatsiya (nekotoryye dokumenty i materialy)].
- Moshkin, Ye.K.: Scientific Papers and Engineering Developments by F.A.Tsander in the Field of Rocket Engineering (Nauchnyye trudy i inzhenernyye razrabotki F.A.Tsandera v oblasti raketnoy tekhniki).
- Okromeshko, N.V.: The First Soviet Aircraft Engine, M II (On the 35th Anniversary of its Realization) [Pervyy sovetskiy aviatsionnyy motor M II (35 let so dnya sozdaniya)].
- Pobedonostsev, Yu.A.: 35 Years since Formulation of the Theory of the Ramjet Engine by Academician B.S.Stechkin (35 let so vremeni sozdaniya akademikom B.S.Stechkinym teorii vozdushno-reaktivnykh dvigateley).
- Putilov, K.A.: Scientific and Experimental Preparation for the Flight Tests of the Ramjet Engine on Aircraft Designed by N.N.Polikarpov and by A.S.Yakovlev in 1939-1944 (Nauchno-eksperimental'naya podgotovka letnykh ispytaniy PVRD na samoletakh konstruktsii N.N.Polikarpova i A.S.Yakovleva)

v 1939-1944 gg).

- Razumov, V.V.: Pages from the History of the Leningrad Jet-Propulsion Study Group (LENGIRD) [Iz istorii Leningradskoy gruppy izucheniya reaktivnogo dvizheniya (LENGIRD)].
- Ruzhitskiy, Ye.I.: Present Helicopter Building and the Prospects for its Development (Sovremennoye vertoletostroyeniye i perspektivy yego razvitiya).
- Skvortsov, G.V.: The Development of Rocket Engines in the United States during World War II (Razvitiye raketnykh dvigateley v SSHA v gody vtoroy mirovoy voyny).
- Skvortsov, G.V.: The Development of Liquid-Propellant Rocket Engines in the United States in 1945-1953 (Razvitiye zhidkostnykh raketnykh dvigateley SSHA v 1945-1953 gg.).
- Shavrov, V.B.: On the 40th Anniversary of the Realization of the First All-Metal Aircraft in the USSR (K 40-letiyu sozdaniya pervogo tsel'nometallicheskogo samoleta v SSSR).
- Shavrov, V.B.: On the 75th Anniversary of the Birth of the Aircraft Designer K.A.Kalinin (K 75-letiyu so dnya rozhdeniya aviakonstruktora K.A. Kalinina).
- Shavrov, V.B.: The State of Russian Aircraft Construction before the October Revolution and in the First Years of Soviet Power (Sostoyaniye otechestvennogo samoletostroyeniya pered Velikoy Oktyabr'skoy sotsialisticheskoy revolyutsiyey i v pervyye gody Sovetskoy vlasti).

In addition, the Section, together with the Sector of the History of USSR Technology of the Institute of History of Natural Science and Technology, USSR Academy of Science, held a joint discussion of the prospectus of the Division of "Aviation Science and Engineering" for the publication of sketches of the history of technology in the USSR in a large number of volumes. The prospectus of the division was prepared by a group of authors headed by Academician A.N. Tupolev. During its discussion by members of the Section, a number of critical remarks and requests, directed toward improvement of the composition of the Division, were made.

The preparation of the handbook "Biobibliogr. Dictionary of USSR Workers in Aviation Science and Technology" (Biobibliografich. slovar' otechestvennykh deyateley aviatsionnoy nauki i tekhniki) was continued. The work on the volumes: "Aircraft Construction" (compiled by V.B.Shavrov), "Aircraft Engines" (compiled by N.V.Okromeshko and M.P.Pal'nikov), "Helicopters" (compiled by A.M. Izakson) and "Aeronautics" (compiled by A.I.Dumchev) has now been completed. The remaining volumes are also scheduled for submission in the next few months.

The Section has recently commenced compilation of a large collective work "Fifty Years of USSR Aviation Science and Engineering" (Aviatsionnaya nauka i tekhnika v SSSR za 50 let) which is to be completed by the 50th Anniversary of the Revolution. Most of the group of authors have been selected, the Editorial Board has been approved, and will be headed by Professor I.F. Obraztsov, Rector of Moscow Aviation Institute imeni Ordzhonikidze, and Doctor of Technical Sciences.

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Leningrad

The Leningrad group of the Section now has 65 members, including 7 professors and 14 Candidates in Sciences. The work of the group is directed by an executive committee composed of P.P.Kvade, I.Ya.Shatoba, F.G.Popov, A.I.Dumchev, I.I.Smaga, A.A.Goleyevskiy, V.L.Korvin, V.S.Mitin, and I.F.Fanechkin.

From January 1963 to April 1964*, a total of twelve sessions were held at Leningrad.

On January 30, 1963, F.G.Popov presented a paper on the activity of Prof. K.P.Boklevskiy, Dean of the Faculty of Naval Architecture, St.Petersburg Polytechnic Institute, in the training of aviation cadres. The author emphasized the great work done by Boklevskiy in organizing theoretical aviation courses at the Faculty of Naval Architecture in 1911, and also noted his role in training aviators in the theoretical disciplines, in the selection of professors and instructors, in the organization of the aerodynamics laboratory, etc.

On March 15, S.N.Podkaminer presented a paper on the subject: "Forty Years of the Civil Air Fleet". The paper evoked wide interest, since it touched on questions of the development of the Civil Air Fleet not only on the historical plane but also on the level of its prospects. He dwelt particularly on the design features of the aircraft of the future, on the striving to attain absolute flight safety and profitability.

On May 23, members of the Section attended a Session of the Academic Council of the Leningrad Branch of IIVeIT (Institute for the History of Natural Science and Technology), and heard a paper by Prof. Kornel'skiy of the Henri Gerlach University on the subject "Study of the History of Science in the United States". This paper gave a general idea of the method of studying the history of science in the United States and its principal trends.

On September 30, I.Ya.Shatoba presented a paper on the subject "The Jet Aircraft of F.G.Geshvend". The author stated that the life of Geshvend was now completely traced and that much of what had been previously unknown was now accurately defined. It was also established that Geshvend began to deal with questions of the design of rocket aeronautic vehicles under the influence of I.I.Treteskiy, who was a friend of his. Furthermore, the author noted the historical significance of Geshvend's work, since his project contained interesting innovations. /47

On October 30, K.F.Kosourov presented a paper on the subject "Naval Aviation, a Historical Review, Design Features, and Prospects of Development". This paper related to the history of science. It gave a detailed characterization of hydroplanes from the very beginning of naval aviation, indicating the design

* Reports of the work done by the Leningrad group before 1963 have been published in Tr. Inst. Istorii Yestestvozn. i Tekhn. Akad. Nauk SSSR, No.45, Moscow (1962), pp.257-258, and in the collected papers: Questions of the History of Natural Science and Technology (Voprosy istorii yestestvoznaniya i tekhniki), No.17, Moscow (1964), pp.262-263.

characteristics of the most widely used types of aircraft. He dwelt in particular on the development of Soviet naval aviation and specifically on the designs by D.P.Grigorovich. In conclusion, the author discussed the prospects of development of naval aviation in the USSR and abroad.

On November 30, a Joint Session of the Section and the Leningrad Aero Club was held in the House of Defense of DOSAAF, on the occasion of the 55th anniversary of the foundation of the All-Russian Aero Club and the 40th anniversary of the beginning of Soviet glider sport. I.Ya.Shatoba, a member of our Section, presented a paper on the role of the All-Russian and Leningrad Aero Clubs in the development of aviation and gliding in this country. This anniversary session was attended by about 350 aviators of all generations, from those who began their work in aviation in 1908 - 1909 down to the present time. The session was highly successful.

On December 25, Yu.A.Val'kova presented a paper on the subject "V.P.Vetchinkin, Outstanding Soviet Aerodynamicist". He told of Vetchinkin's work in aerodynamics, emphasized that he also had done work on stress analysis of aircraft and had written a number of papers on air navigation, astronomy, ballistics, jet flight, etc., which are among the most precious treasures of our aviation science.

On January 9, 1964, L.L.Kerber presented a paper on the subject "The 75th Birthday of Academician A.N.Tupolev". This long paper gave a detailed description of Tupolev's career, beginning with his first steps in the field of aviation down to the present. Kerber discussed the path traveled by the designer ⁴⁸ Tupolev from his first aircraft ANT-1 to the most recent jet liners, known far beyond the borders of the USSR. He emphasized the great organizational talent of Tupolev, his profound theoretical knowledge, and his bold conceptions in designing each new aircraft.

In conclusion, the speaker warmly lauded the personal characteristics of Andrei Nikolayevich Tupolev as a chief designer, a man, and a colleague.

On February 5, P.P.Kvade presented a paper "The 60th Birthday of Aviator Chkalov". It discussed in detail his life, emphasizing his striving, as a young man, to obtain an appointment to the Civil Air Fleet, his great aptitude for flying, and his perseverance in the work of an aviator. He noted Chkalov's energy, his work as a test pilot, where his flying skill and his knowledge as a test pilot manifested themselves in a particularly impressive manner.

After the paper, a coworker of Chkalov, V.Zarkhi, a retired mechanic, presented his recollections.

On February 26, two papers were presented:

A.I.Dumchev "30 Years since the Flight of the Stratosphere Balloon 'OSO-AVIAKhIM-1' to an altitude of 22,000 meters".

I.Ya.Shatoba "The Rocket-Powered Balloon of I.I.Tretesskiy".

On April 1, B.G.Broude gave a talk on the designer S.V.Il'yushin (in honor

of his 70th birthday).

The Leningrad group of the Section has the following plans for the near future:

Expand the mutual exchange of work experience, by news items and papers on topics of current interest.

Continue popularization of the work of the Section in Leningrad, actively enlist in its work all persons working in the related research organizations.

Enlarge and deepen debates on books in aeronautics, aviation, and astronautics.

Actively promote further work on the collection of data for a handbook on the history of aviation in St.Petersburg-Leningrad, publication of which is scheduled for the Fiftieth Anniversary of the Revolution.

Kiev

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The Kiev group of the Section was organized in February 1962. It now has 31 members. The work of the group is directed by a committee composed of: M.A.Kochegura (Chairman), I.S.Laponogov (Vice Chairman), Ye.V.Koroleva (Academic Secretary), M.B.Lyakhovetskiy and N.S.Shelukhin (Members of the Committee).

In two years in Kiev, a total of 16 sessions of the Section were held, at which a large number of papers and communications were presented. A detailed report of the Kiev group will be published in one of our next issues.

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